



## Coding in the tactile system

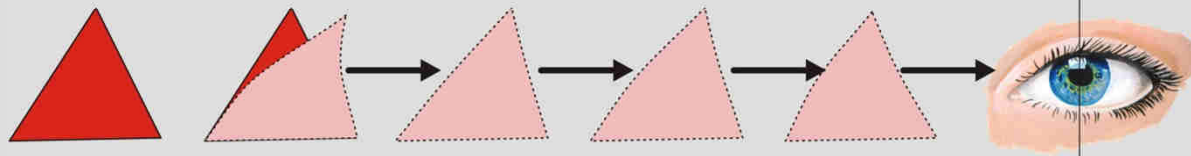
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*Werner Reichardt Center for Integrative Neuroscience  
Hertie Institute for Clinical Brain Research  
Eberhard Karls University  
Tübingen*



## *The outside of a perceptive system*

The image flakes (idols, εἰδωλα) of  
Democritus & Epicurus



outside

inside the  
perceptive system



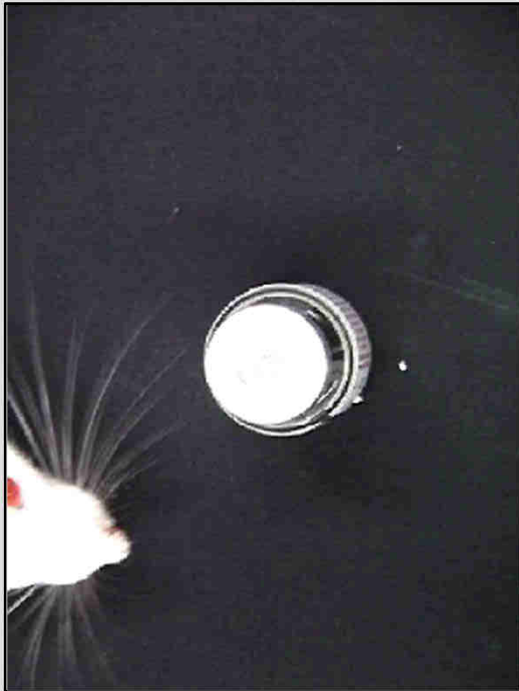
## *Two determinants reign on the outside of perception*

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Szyszka 2014

- 1) **The Physical Constraints** – how are the sensory data conveyed to the sense organ?
- 2) **Ego Motion** – the behavioral strategy to collect sensory data



## *Touch with fingers or whiskers are active scanning systems*

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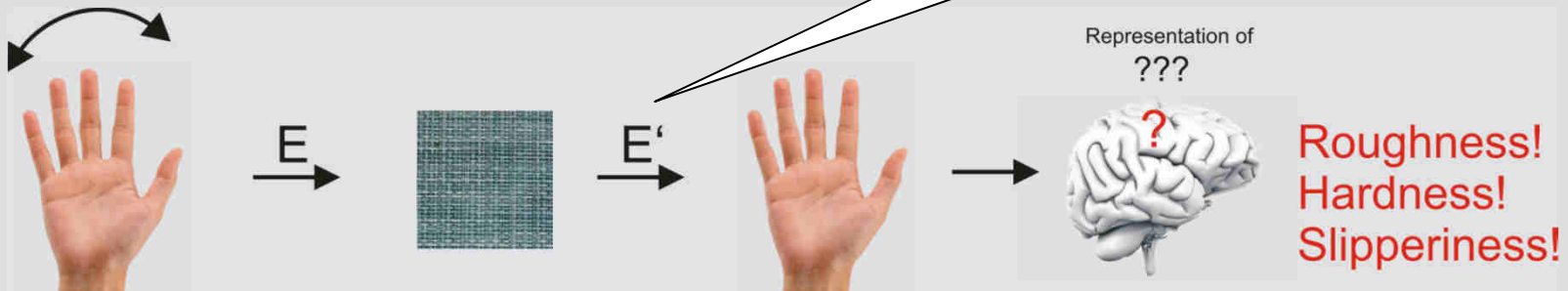
**Active scanning:** deploy energy into the world and make use of its reflections

echo location in whales/bats

electric sense of fish

and touch

E is movement,  
but what is E' ???

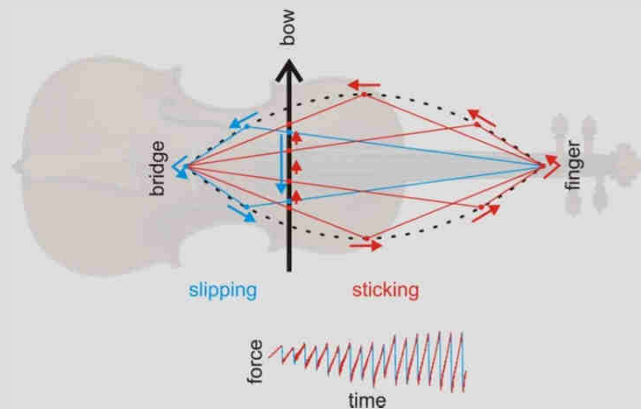


## *The physical constraints: Slips*

What is shared by these objects?

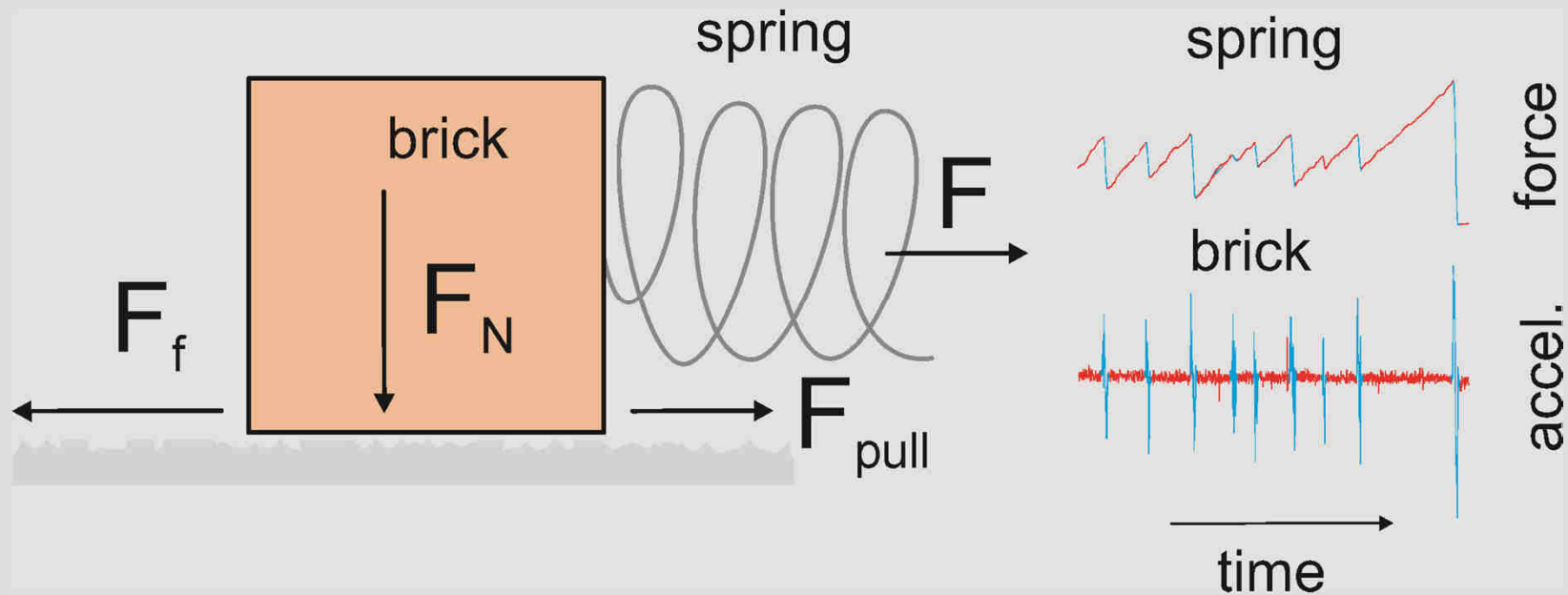


They are cause or effect of frictional movement !



Frictional movement is characterized by stick-slip movements

*Slips are discrete, temporally local informational events...*



*...not unlike spikes in a neuronal network!*

## *Determinants of (active) touch: friction and scanning strategy*

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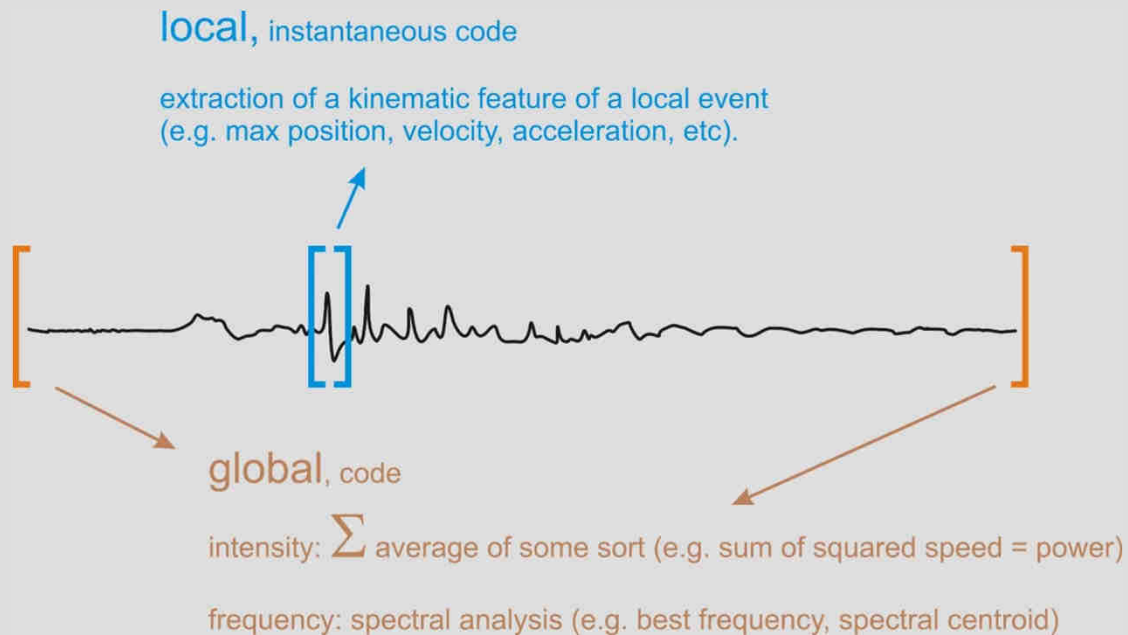
Oladazimi, Brendel, Schwarz Sci. Reports 2018

- 1) **The Physical Constraints** – the sensory data are conveyed via frictional movement (slips)
- 2) **Ego Motion** – movement parameters (setpoint, speed, etc.)



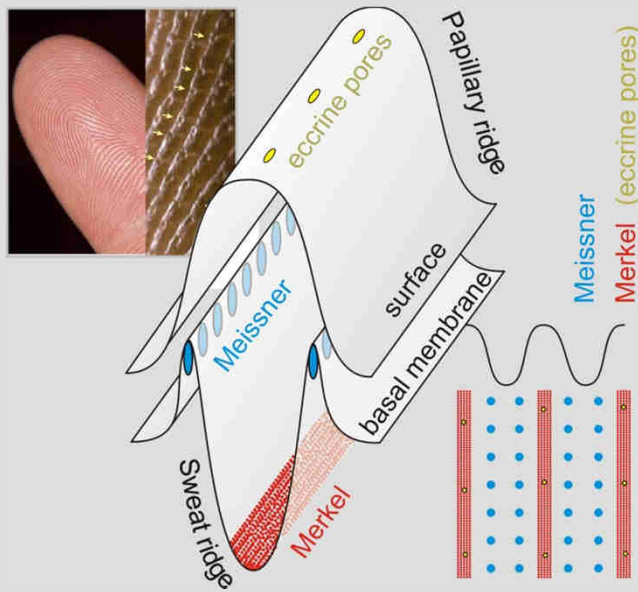
## *Slip hypothesis*

- Microscopic texture properties (e.g. roughness) are encoded in frictional slips
- Encoding in short-lasting slip events (< 15 ms) begs a temporally local code rather than the classically discussed global codes



## *Slip hypothesis (cont.)*

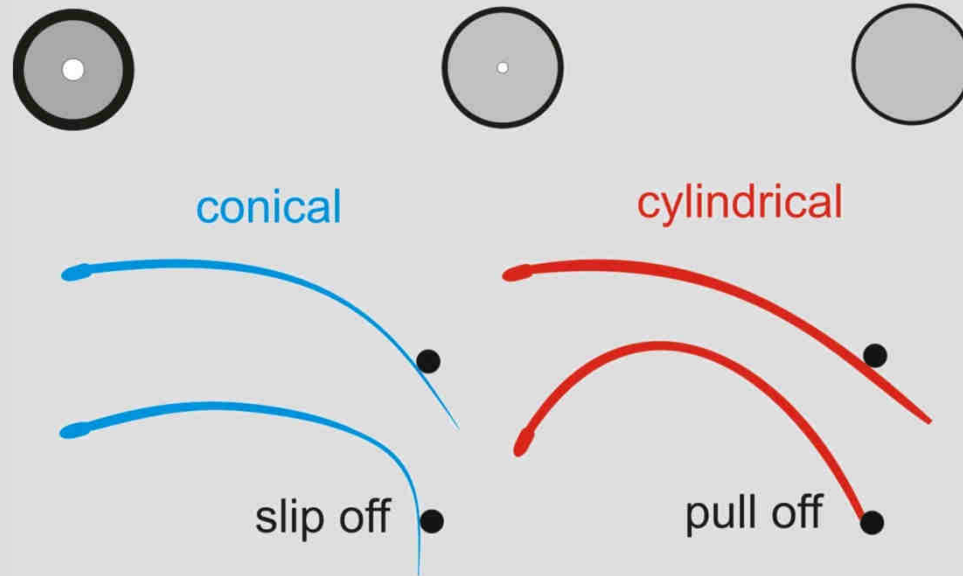
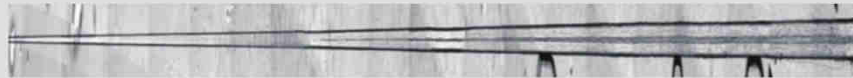
- The slip hypothesis may provide an answer to the question why we have a fingerprint, and explain the exquisite structure of papillary ridges and related mechano-sensors.



Thonnard lab UC Louvain

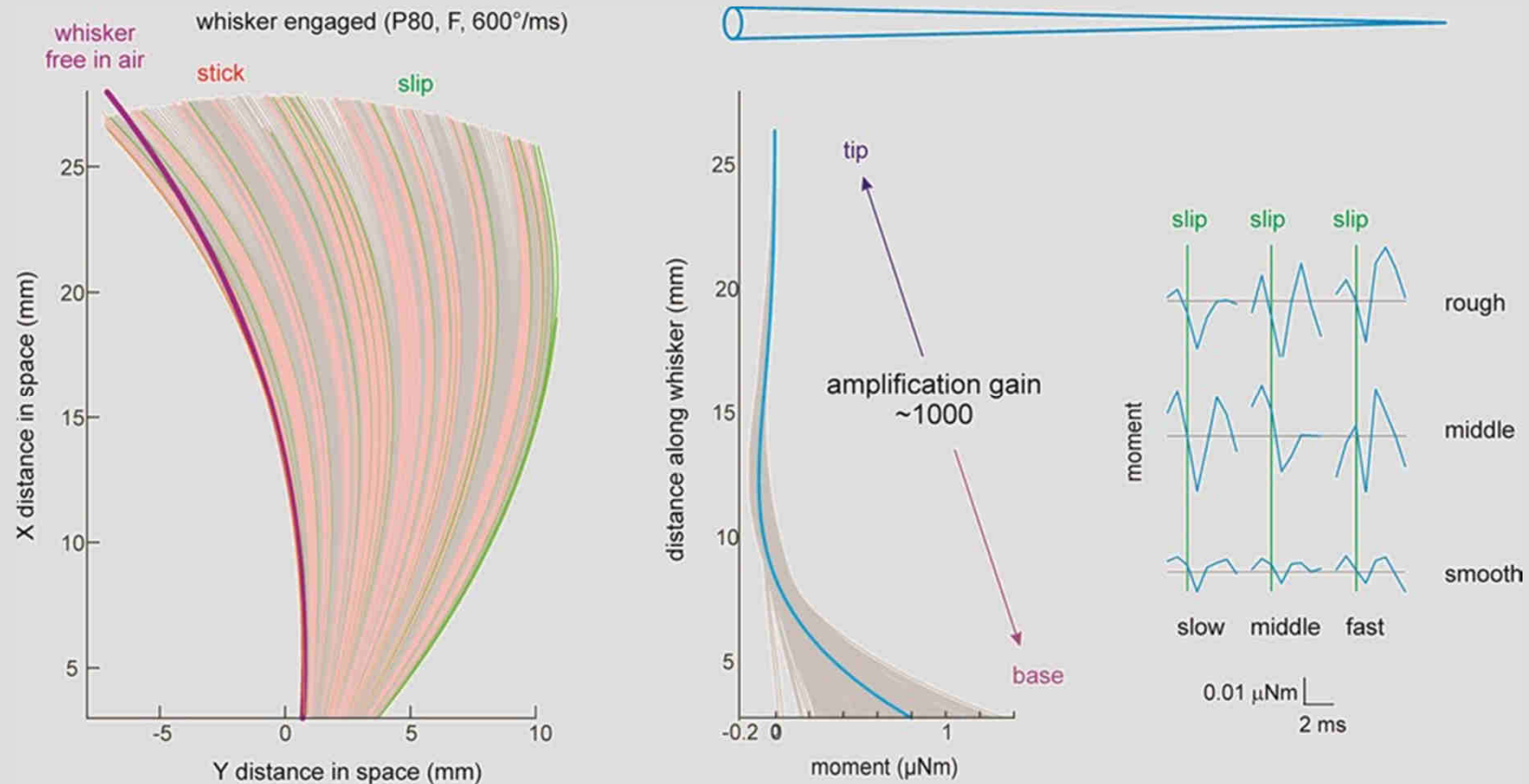
## *Whiskers seem to be made for slipping*

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Towal et al., 2011  
Voges et al., 2012  
Hires et al., 2013

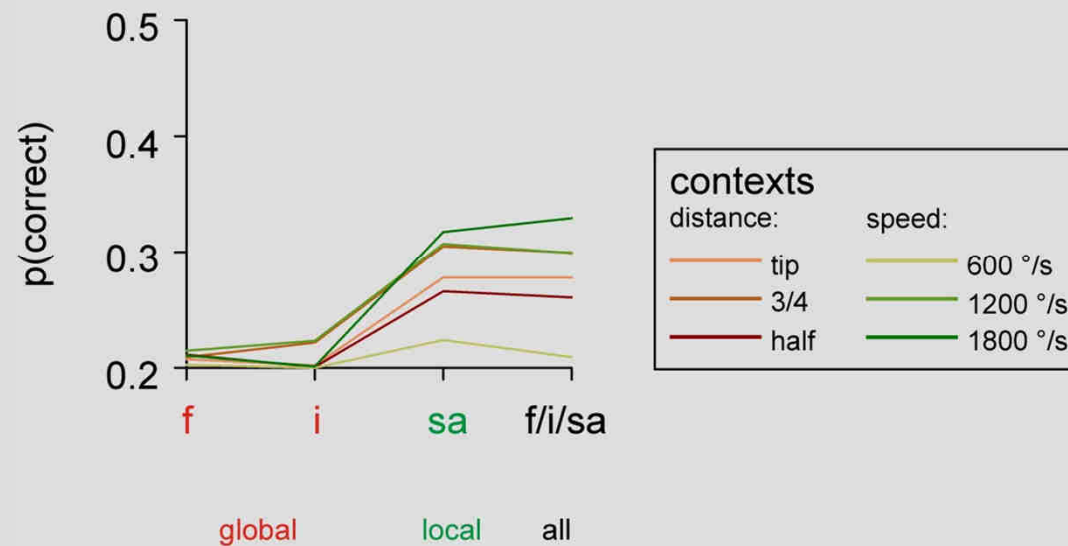
## *Slips are converted into strongly amplified moment events along the whisker*



## Biomechanics: Local coding is better than global coding

whisker A2

identification of one sandpaper out of five  
chance level  $p=0.2$

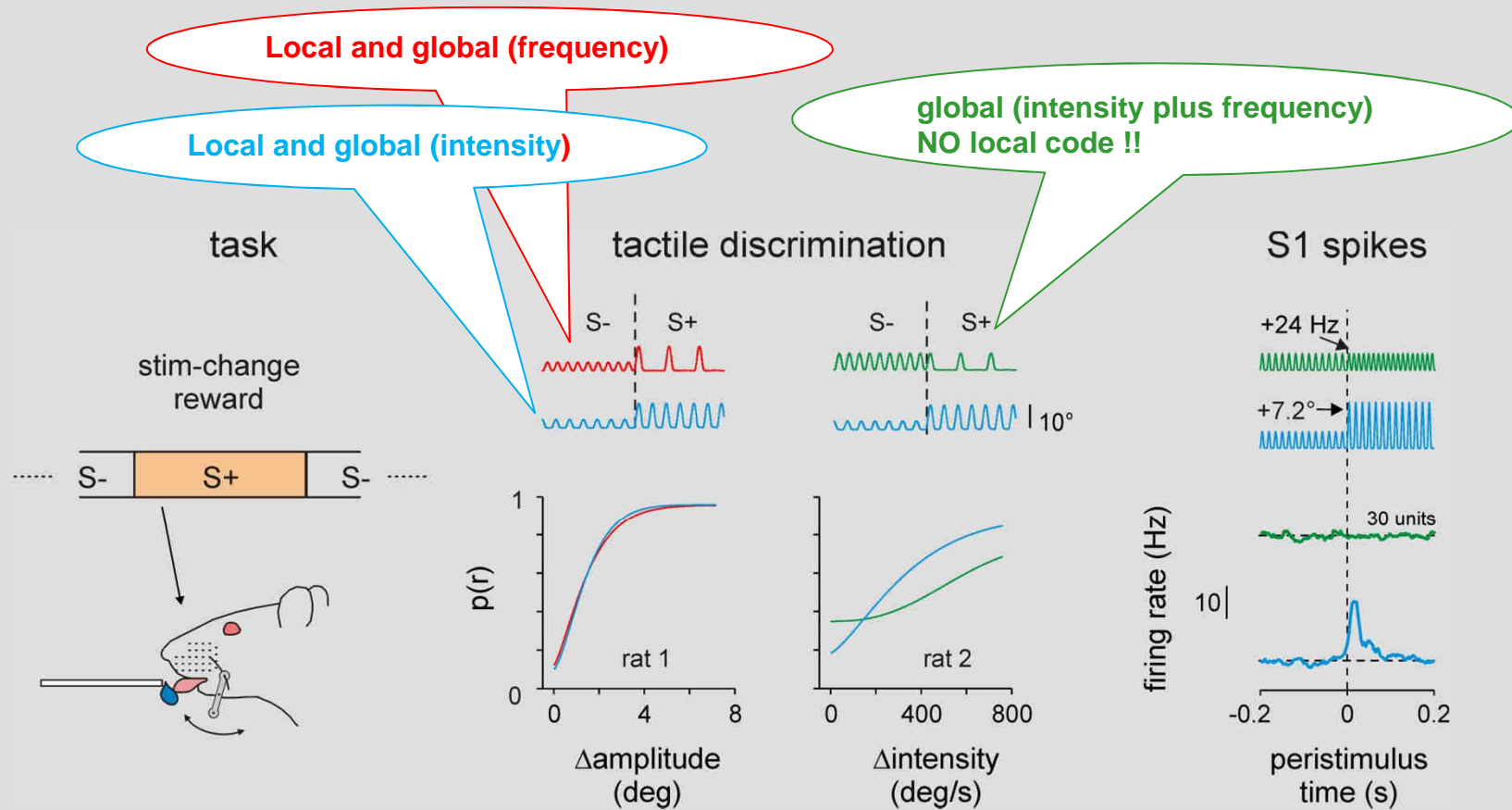


f (frequency), i (intensity)

sa (slip acceleration)

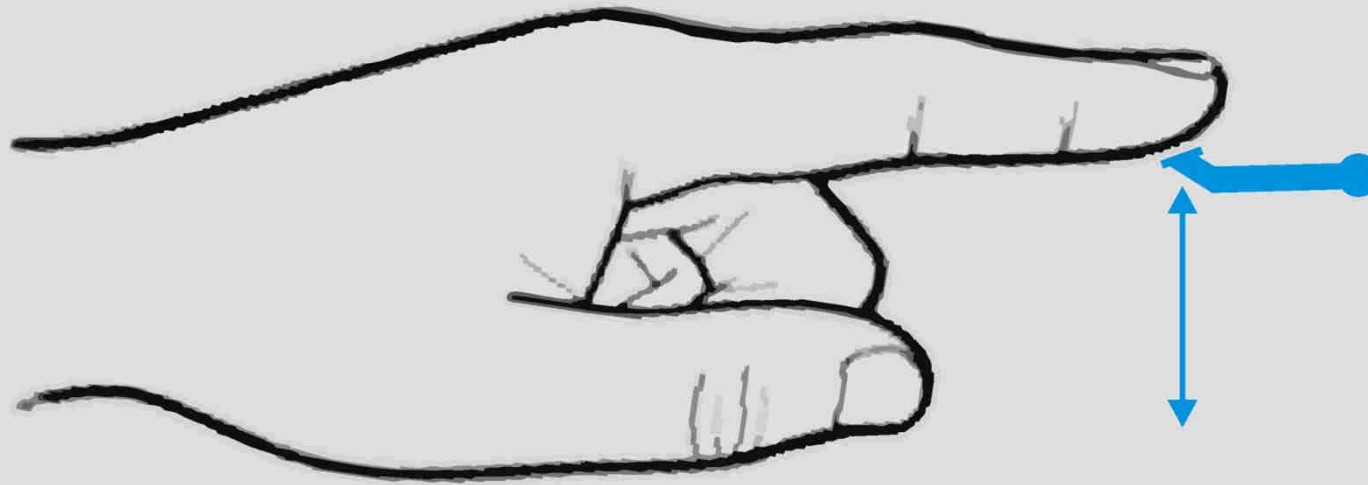
f/i/sa (all three)

# Psychophysics and S1 spikes: Strongly indicative of coding of short (local!!) events

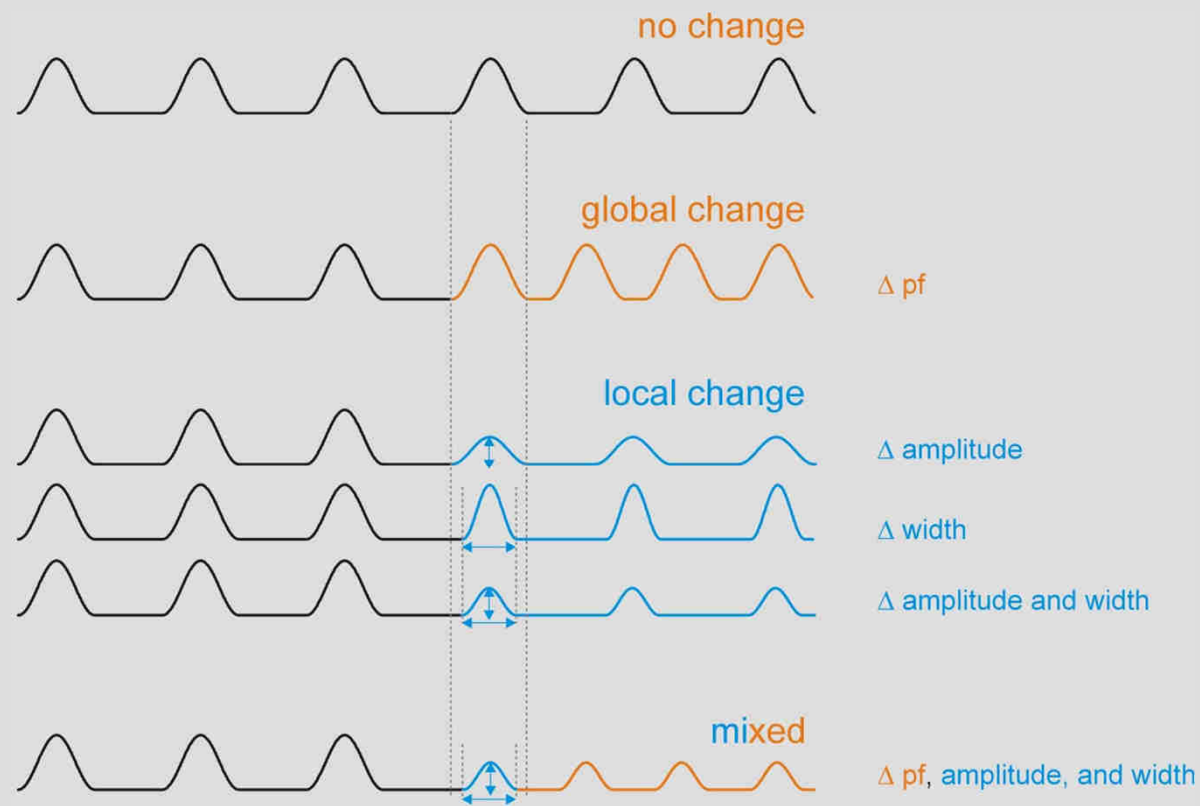


*Psychophysical experiment in humans*

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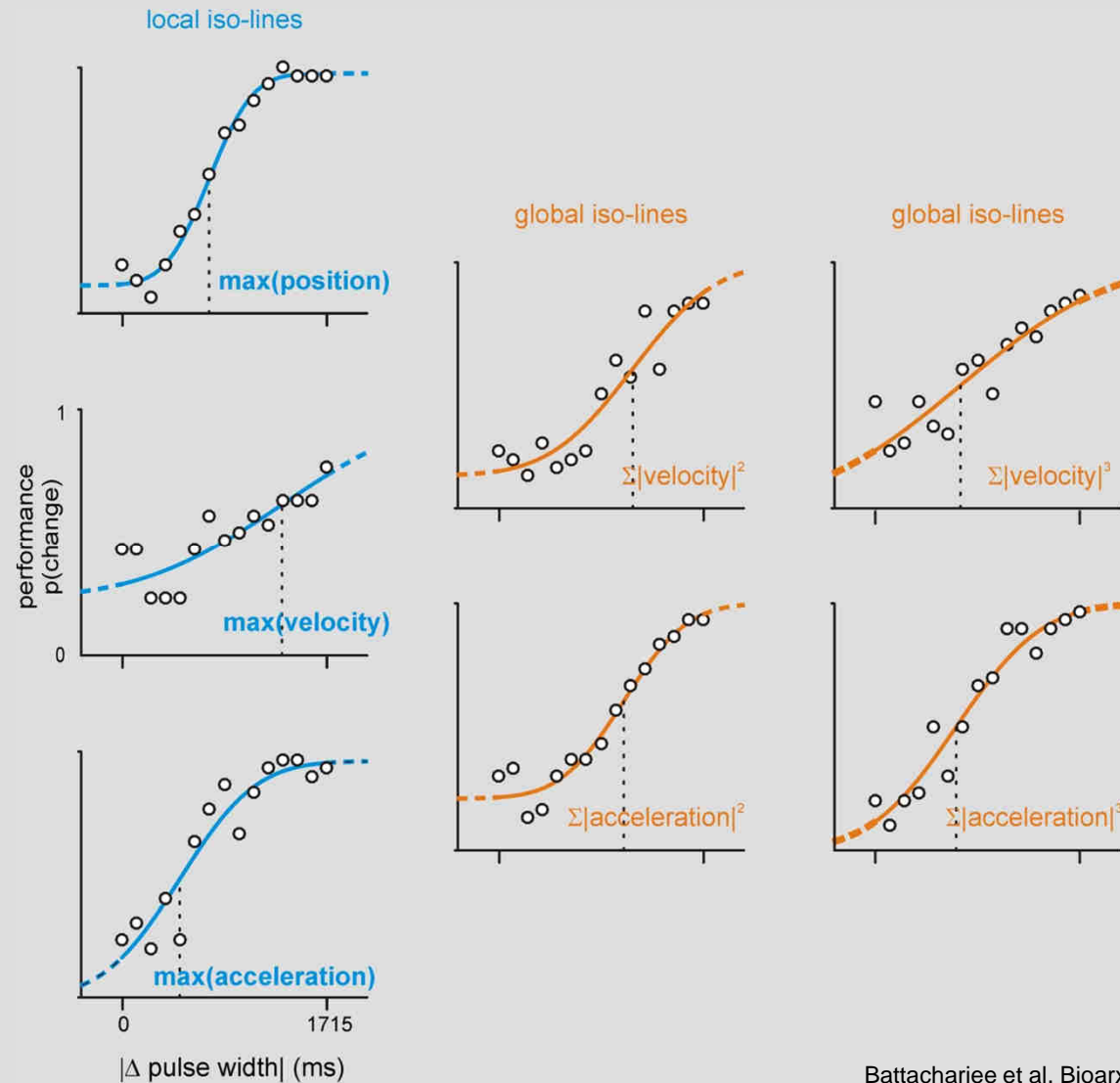
“Indicate if you perceived  
a stimulus change!” (Yes / No)



20  $\mu m$  | 10 ms



## *Performance is worst when maximal absolute velocity is kept constant*



## *Summary*

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1. Frictional movements fundamentally transform 3D surface information into series of slip events embedded in noise.
2. Slips relay high rates of texture information.
3. Slips are susceptible to sensor movements.
4. Slips generated at the tip of the whisker are instantly conveyed to the base by 2nd mode of bending.
5. The moment is amplified by a factor of  $\sim 1000$  from tip to base.
6. The information reaching the brain is about kinematic details of slip-like events - short strips of trajectory, 10 ms in duration.
7. Rats extract tactile information contained in slip-like short events rather than integrating the signal.
8. Humans extract information contained in short events
9. **Slip hypothesis: Tactile perception depends on event waveforms – less on integrated variables.**